PERFORMANCE INVESTIGATION OF A SMALL FOUR-STROKE CARBURETTED SI ENGINE

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Automotive Engineering.

Signature

Name of Supervisor: MOHD RAZALI BIN HANIPAH

Position: Lecturer

Date:

STUDENT'S DECLARATION

I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurrently submitted for award of other degree.

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ABSTRACT

A small four-stroke carburetted SI engine is a mechanism which normally apply to motorcycle, lawn mowers or small machines that use gasoline. The purpose of this project is to assess the extent to which the performance of this engine can be taken as a benchmark for the development of the packaging. The modelling to develop one-dimensional model of a small four-stroke carburetted SI engine is done by GT-POWER software. Once the model is developed, it will undergo to the process of simulation, then performance parameters will be recorded for investigation. In addition to the simulation method, the experiments were also carried out is done by a single test bed dynamometer as. After taken the performance parameter result, comparison of parameters between experiment and simulation methods will be carried out. After completion of the two methods, the results showed that all parameters not valid for the speed of 2600rpm because there is a high percentage difference. Therefore, simulation modelling should be improved so that this one-dimensional can be use for benchmarking in order to improve future small four-stroke packaging.

ABSTRAK

Enjin kecil percikan pengapian karburator empat lejang adalah satu mekanisma dimana kebiasaannya diguna pakai untuk motosikal, mesin rumput atau mesin kecil yang menggunakan minyak petrol. Tujuan projek ini adalah untuk menilai sejauh mana prestasi enjin ini boleh diambil sebagai kayu ukur untuk pembangunan pembungkusan. Penggunaan perisian GT-POWER adalah antara kaedah yang digunakan adalah membangunkan model satu-dimensi enjin kecil percikan pengapian karburator empat lejang. Setelah model ini dibangunkan, ianya akan menjalani proses simulasi dan hasil daripada simulasi tersebut, parameter prestasi akan direkodkan untuk disiasat. Selain kaedah simulasi, penggunaan dinamometer sebagai kaedah eksperimen juga dijalankan. Setelah maklumat parameter diambil, perbandingan parameter di antara kaedah eksperimen dan simulasi akan dijalankan. Setelah selesai kedua-dua kaedah, keputusan yang diperolehi menunjukkan semua parameter tidak berlaku untuk kelajuan 2600rpm dan ke atas kerana ada peratusan perbezaan yang tinggi. Oleh itu, pemodelan simulasi harus dipertingkatkan sehingga satu-dimensi ini dapat digunakan untuk pembandingan dalam rangka meningkatkan bungkusan enjin kecil empat lejang.

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CHAPTER 1

INTRODUCTION

1.1 PROJECT BACKGROUND

An engine is a mechanical device that produces some form of output from a given input. The purpose of the engine is to produce kinetic energy output from a fuel source is called a prime mover; alternatively, a motor is a device which produces kinetic energy from a preprocessed "fuel" (such as electricity, a flow of hydraulic fluid or compressed air).

A motor car (automobile) has a starter motor and motors to drive pumps (fuel, power steering, etc) – but the power plant that propels the car is called an engine. The term 'motor' was originally used to distinguish the new internal combustion engine -powered vehicles from earlier vehicles powered by a steam engine.

1.2 PROBLEM STATEMENT

Each device or machine made by companies around the world must have the best packaging system. For this project, a small four-stroke SI engine is plagued by power to weight ratio issue. The current trend is to improve the engine packaging in order to increase the power to weight ratio. To solve this problem, a performance investigation is to be conducted along with a one-dimensional model of this engine to provide a benchmarking for the packaging improvement.

1.3 OBJECTIVE

The objective of this project are:

i. To develop a one-dimensional model of a 4-stroke SI engine using GT-Power.
ii. To simulate the one-dimensional model and obtain the performance parameters.
iii. To experimentally evaluate engine performance parameters of a small 4-stroke carburetted SI engine.

1.4 SCOPES OF WORK

The scope of project covered obtain and produce about 4-stroke SI engine performance using dynamometer testing and GT-Power software. The scope of this project consists of this below:

i. The engine use for this investigation is Honda G200.
ii. The software use for modelling and simulation of Honda G200 engine is done by using GT-Power software.
iii. Performance parameters in concerned are torque, power and specific fuel consumption.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

In this chapter, it will discuss about the previous researches that have been done about the related issues with this project. The definition of each term is also included. Engine performance parameters such as brake torque, brake power, brake specific fuel consumption are interested terms in this chapter. The source of the literature review is from journals, articles and books. Literature review is done to provide information about previous research and the relevant that can help to smoothly run this project.

2.2 INTERNAL COMBUSTION ENGINE

2.2.1 Historical Perspective

The first gasoline-fuelled, four-stroke cycle engine was built in Germany in 1876. In 1886, Carl Benz began the first commercial production of motor vehicles with internal combustion engines. By the 1890s, motor cars reached their modern stage of development. In fact, the models of that decade were so successful that there has been no fundamental change in the principles of the ordinary automobile engine since that time.

It took several more years for the internal combustion engine to sweep the American market, however. General conditions, such as the expansiveness of the nation, the lack of decent roads, and the relatively well-developed urban transit system, worked against adoption of any and all motor vehicles for a time. Mass production of gasoline-powered cars, however, brought to the market a vehicle that was modestly priced, easy to maintain, relatively fast and powerful, able to travel long distances, and fuelled by a cheap, abundant, widely-available source of energy. Figure 2.1 shows the first true four stroke cycle introduced by Nicolaus A. Otto. (Martin V. Melosi)

Figure 2.1: First true 4-stroke cycle in 1876

An atmospheric engine introduced in 1867 by Nicolaus A. Otto (1832-1891) and Eugen Langen (1833-1895 used the pressure rise resulting from combustion of the fuel-air charge early in the outward stroke to accelerate a free piston and rack assembly so its momentum would generate a vacuum in the cylinder. Atmospheric pressure then pushed the piston inward, with the rack engaged through a roller clutch to the output shaft. Production engines, of which about 5000 were built, obtained thermal efficiencies of up to 11 percent. A slide valve controlled intake, ignition by a gas flame and exhaust. (John B. Heywood, 1988)

To overcome this engine's performance shortcomings of low thermal efficiency and excessive weight, Otto proposed an engine cycle with four piston strokes, an intake stroke, then a compression stroke before ignition, an expansion or power stroke where work was delivered to the crankshaft and finally an exhaust stroke. His also proposed incorporating a stratified-charge induction system, through this was not achieved in practice. His prototype four-stroke engine first ran in 1876. A comparison between the Otto engine and its atmospheric-type predecessor indicates the reason for its success, the enormous reduction in engine weight and volume. This was the breakthrough that effectively founded the internal combustion engine industry. By 1890, almost 50,000 of these engines had been sold in Europe and the United States.

2.2.2 Development

Engine development, perhaps less fundamental but nonetheless important to the steadily widening internal combustion engine markets, have continued ever since. One more recent major development has been the rotary internal combustion engine. Although a wide variety of experimental rotary engines have been proposed over the years, the first rotary internal combustion engine, the Wankel, was not successfully tested until 1957. That engine, which evolved through many years of research and development, was based on the designs of the German inventor Felix Wankel. (Wankel, F. 1965)

2.2.3 The Differences Between A Two Stroke And Four Stroke Engine

According to R. Kayne (2010), to understand the mechanical differences between a two stroke and four stroke engine, lets first consider how the four stroke engine works as Figure 2.2. The four strokes are:

Intake: The piston travels down the cylinder while the intake valve is opened to allow a mixture of fuel and air to enter the combustion chamber.

Compression: The intake valve is closed and the piston travels back up the cylinder thereby compressing the gasses.

Combustion: The spark plug ignites the compressed gas causing it to explode, which forces the piston down.

Exhaust: The piston rises up the cylinder as the exhaust valve is opened, allowing the piston to clear the chamber to start the process over.

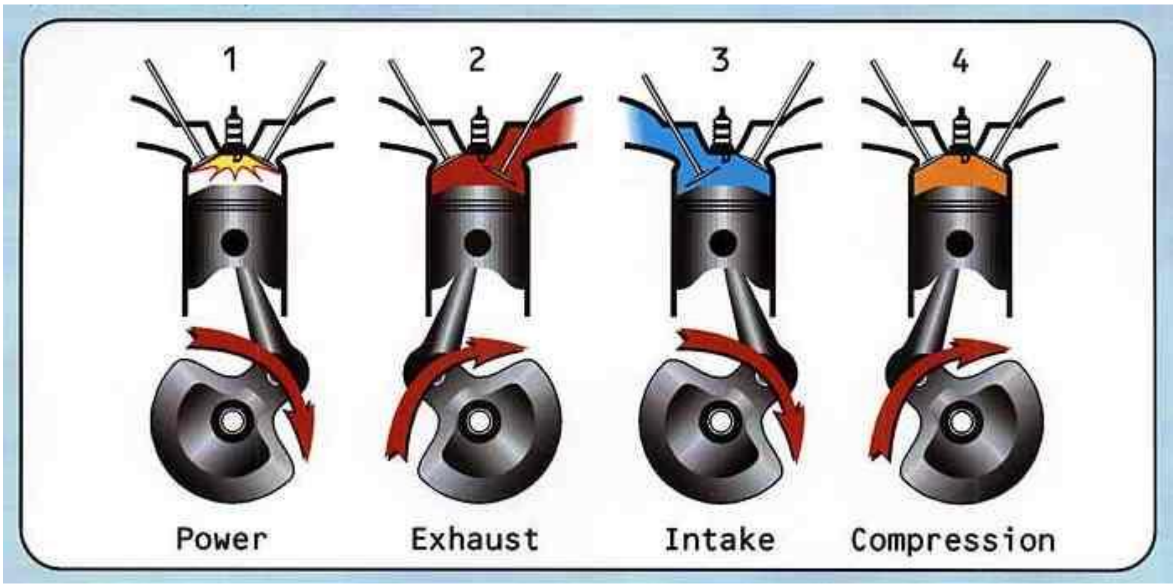

Figure 2.2: Cycle of four stroke engine

Each time the piston rises and falls it turns the crankshaft that is responsible for turning the wheels. This is how fuel is converted into forward motion. Of note here is that the spark plug *only fires once every other revolution*. Also, there is a sophisticated set of mechanisms working in synchronization to create the four strokes. A camshaft must alternately tip a rocker arm attached either to the intake or exhaust valve. The rocker arm returns to its closed position via a spring. The valves must be seated properly in the cylinder head to avoid compression leaks. In other words, a symphony of mechanical events occurs.

In the two stroke engine, all four events are integrated into one simple downward stroke, and one upward stroke. Two strokes. *Intake and exhaust are both integrated into the compression and combustion movement of the piston*, eliminating the need for valves. This is accomplished by an inlet and exhaust port in the wall of the combustion chamber itself. As the piston travels downward from combustion, the exhaust port is exposed allowing the spent gasses to rush out of the chamber. The downward stroke also creates suction that draws in new air/fuel through an inlet located lower in the chamber. As the piston rises again, it blocks off the inlet and port, compressing the gasses at the top of the chamber. The spark plug fires and the process starts over. Significantly, *the engine fires on every revolution*, giving the two stroke its power advantage.

However, at the lowest point of travel of the piston when the chamber is filling with fuel/air, the exhaust port exposed above allows some fuel/gasses to escape the chamber. This is easily seen with an outboard motorboat, evident by the multicolored oil slick surrounding the engine, but it happens with all two stroke engines. This along with burning oil creates pollution and fuel-efficiency issues.

For these reasons, two stroke engines are reserved for intermittent use, where weight-to-power ratio or orientation issues are important and where mileage isn't primary. Meanwhile manufacturers are looking for ways to add advantages to four stroke motors, making them smaller, lighter and more robust.

2.3 ENGINE PERFORMANCE PARAMETERS

The practical engine performance parameters of interest are power, torque, and specific fuel consumption. Power and torque depend on an engine’s displaces volume. A set of normalized or dimensionless performance and emissions parameters were defined to eliminate the effects of engine size.

Engine torque is normally measured with a dynamometer. The engine is clamped on a test bed and shaft is connected to the dynamometer rotor. Figure 2.3 illustrates the operating principle of a dynamometer. The rotor is coupled

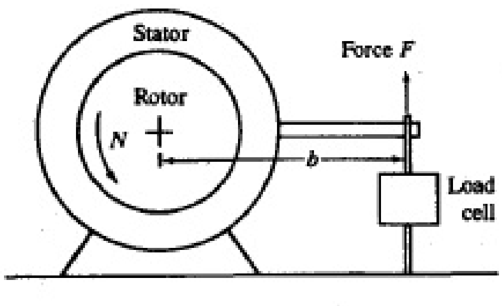

Figure 2.3: Schematic principle operation of dynamometer.

electromagnetically, hydraulically or by mechanical friction to a stator which is supported in low friction bearings. The stator is balanced with the rotor stationary. The torque exerted on the stator with the rotor turning is measured by balancing the stator with weights, springs or pneumatic means.

Using the notation in Figure 2.3, if the torque exerted by the engine is T :

$$T = Fb \tag{2.1}$$

The power P delivered by the engine and absorbed by the dynamometer is the product of torque and angular speed :

$$\mathrm{P} = 2\pi \mathrm{NT} \tag{2.2}$$

where N is the crankshaft rotational speed. In SI units :

$$P(\mathrm{kW}) = 2\pi N(\mathrm{rev/s}) T(\mathrm{N.m}) \times 10^{-3} \tag{2.3}$$

or in U.S. units :

$$P(\mathrm{hp}) = \frac{N(\mathrm{rev/min})\ T(\mathrm{lbf.ft})}{5252} \tag{2.4}$$

Note that torque is a measure of an engine's ability to do work, power is the rate at which work is done.

The value of engine power measured as described above is called *brake power* P_b. The power is the usable power delivered by the engine to the load.

Using these normalized parameters, the effect of engine size can be made explicit. The power P can be expressed as :

$$\begin{aligned} P &= \mathrm{mep}\ A_p \bar{S}_p/4 \quad \text{(four-stroke cycle)} \\ P &= \mathrm{mep}\ A_p \bar{S}_p/2 \quad \text{(two-stroke cycle)} \end{aligned} \tag{2.5}$$

The torque T is given by

$$T = \text{mep}\ V_d/(4\pi) \quad \text{(four-stroke cycle)}$$
$$T = \text{mep}\ V_d/(2\pi) \quad \text{(two-stroke cycle)} \qquad (2.6)$$

Thus for well-designed engines, where the maximum values of mean effective pressure and piston speed are either flow limited (in naturally aspirated engines) or stress limited (in turbocharged engines), power is proportional to piston area and torque to displaced volume. Mean effective pressure can be expressed as

$$\text{mep} = \eta_f \eta_v Q_{\text{HV}} \rho_{a,i} \left(\frac{F}{A}\right) \qquad (2.7)$$

for four-stroke cycle engines, and as

$$\text{mep} = \eta_f \eta_v \Lambda Q_{\text{HV}} \rho_{a,i} \left(\frac{F}{A}\right) \qquad (2.8)$$

for two-stroke cycle engines. The importance of high fuel conversion efficiency, breathing capacity, and inlet air density is clear. Specific fuel consumption is related to fuel conversion efficiency and can be expressed as

$$\text{sfc} = \frac{1}{\eta_f Q_{\text{HV}}} \qquad (2.9)$$

These parameters have both brake and indicated values. The difference between these two quantities is the engine's friction (and pumping) requirements and their ratio is the mechanical efficiency η_m.

Then over the whole operating range, and most especially those parts of that range where the engine will operate for long periods of time, engine fuel consumption and efficiency, and engine emissions are important. Since the operating and emissions characteristics of spark-ignition and compression-ignition engines are substantially different, each engine type is dealt with separately.

2.4 ENGINE TESTING

2.4.1 Introduction to engine testing

Today‘s engines and components require testing in a repeatable manner over a wide variety of conditions, ensuring that the final manufactured product consistently meets customer demands for performance and durability. The need for engines to be both economical and - above all - environmentally friendly, places fresh challenges on developers.

The ever-increasing complexity of engine systems, new emissions legislation and reduction of development time and cost are crucial in the development of engine test systems. When developing new products even small improvements can create a leading edge, providing you with a decisive advantage over the competition. Engine sizes range from very small engines used for auxiliary purposes or small motor cycles, through the light duty range to heavy duty engines.

2.4.2 Benchmarking

According to A.J. Martyr and M.A. Plint (2007), cross-referencing with other test facilities or test procedures is always useful when specifying your own. Benchmarking is merely a modern term for an activity that has been practiced by makers of products intended for sale, probably ever since the first maker of flint axes went into business: it is the act of comparing your product with competing products and your production and testing methods with those of your competitors. The difference today is that it is now highly formalized and practiced without compunction. Once it is on the market any vehicle or component thereof can be bought and tested by the manufacturer’s competitors, with a view to taking over and copying any features that are clearly in advance of the competitor’s own products. There are test facilities built and run specifically for benchmarking.

This evidently increases the importance of patent cover, of preventing the transfer of confidential information by disaffected employees and of maintaining confidentiality during the development process, such concerns need to have preventative measures built into the specification of the facility rather than added as an afterthought.